PATENT COOPERATION TREATY

From the
INTERNATIONAL PRELIMINARY EXAMINING AUTHORITY

To:

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PCT

NOTIFICATION OF TRANSMITTAL OF THE INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY

(PCT Rule 71.1)

Date of mailing *(day/month/year)*	17.07.2006
Applicant's or agent's file reference VELOP0115WO	**IMPORTANT NOTIFICATION**

International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/US2005/000623	07.01.2005	11.02.2004

Applicant
VELOCYS INC. et al.

1. The applicant is hereby notified that this International Preliminary Examining Authority transmits herewith the international preliminary report on patentability and its annexes, if any, established on the international application.

2. A copy of the report and its annexes, if any, is being transmitted to the International Bureau for communication to all the elected Offices.

3. Where required by any of the elected Offices, the International Bureau will prepare an English translation of the report (but not of any annexes) and will transmit such translation to those Offices.

4. **REMINDER**

The applicant must enter the national phase before each elected Office by performing certain acts (filing translations and paying national fees) within 30 months from the priority date (or later in some Offices) (Article 39(1)) (see also the reminder sent by the International Bureau with Form PCT/IB/301).

Where a translation of the international application must be furnished to an elected Office, that translation must contain a translation of any annexes to the international preliminary report on patentability. It is the applicant's responsibility to prepare and furnish such translation directly to each elected Office concerned.

For further details on the applicable time limits and requirements of the elected Offices, see Volume II of the PCT Applicant's Guide.

The applicant's attention is drawn to Article 33(5), which provides that the criteria of novelty, inventive step and industrial applicability described in Article 33(2) to (4) merely serve the purposes of international preliminary examination and that "any Contracting State may apply additional or different criteria for the purposes of deciding whether, in that State, the claimed inventions is patentable or not" (see also Article 27(5)). Such additional criteria may relate, for example, to exemptions from patentability, requirements for enabling disclosure, clarity and support for the claims.

Name and mailing address of the international preliminary examining authority:	Authorized Officer
European Patent Office D-80298 Munich Tel. +49 89 2399 - 0 Tx: 523656 epmu d Fax: +49 89 2399 - 4465	Spira, C Tel. +49 89 2399-7096

PATENT COOPERATION TREATY

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INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY

(Chapter II of the Patent Cooperation Treaty)

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference VELOP0115WO	**FOR FURTHER ACTION**	See Form PCT/IPEA/416
International application No. PCT/US2005/000623	International filing date *(day/month/year)* 07.01.2005	Priority date *(day/month/year)* 11.02.2004
International Patent Classification (IPC) or national classification and IPC INV. B01J19/00		
Applicant VELOCYS INC. et al.		

1. This report is the international preliminary examination report, established by this International Preliminary Examining Authority under Article 35 and transmitted to the applicant according to Article 36.
2. This REPORT consists of a total of 8 sheets, including this cover sheet.
3. This report is also accompanied by ANNEXES, comprising:
   a. ☒ *sent to the applicant and to the International Bureau)* a total of 13 sheets, as follows:
      ☒ sheets of the description, claims and/or drawings which have been amended and are the basis of this report and/or sheets containing rectifications authorized by this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions).
      ☐ sheets which supersede earlier sheets, but which this Authority considers contain an amendment that goes beyond the disclosure in the international application as filed, as indicated in item 4 of Box No. I and the Supplemental Box.
   b. ☐ *(sent to the International Bureau only)* a total of (indicate type and number of electronic carrier(s)) , containing a sequence listing and/or tables related thereto, in electronic form only, as indicated in the Supplemental Box Relating to Sequence Listing (see Section 802 of the Administrative Instructions).

4. This report contains indications relating to the following items:

☒	Box No. I	Basis of the report
☒	Box No. II	Priority
☐	Box No. III	Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
☐	Box No. IV	Lack of unity of invention
☒	Box No. V	Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
☐	Box No. VI	Certain documents cited
☒	Box No. VII	Certain defects in the international application
☒	Box No. VIII	Certain observations on the international application

Date of submission of the demand	Date of completion of this report
27.07.2005	17.07.2006
Name and mailing address of the international preliminary examining authority: European Patent Office D-80298 Munich Tel. +49 89 2399 - 0 Tx: 523656 epmu d Fax: +49 89 2399 - 4465	Authorized officer Nazario, L Telephone No. +49 89 2399-8137

INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY

International application No.
PCT/US2005/000623

Box No. I Basis of the report

1. With regard to the **language**, this report is based on

   ☒ the international application in the language in which it was filed

   ☐ a translation of the international application into , which is the language of a translation furnished for the purposes of:
   - ☐ international search (under Rules 12.3(a) and 23.1(b))
   - ☐ publication of the international application (under Rule 12.4(a))
   - ☐ international preliminary examination (under Rules 55.2(a) and/or 55.3(a))

2. With regard to the **elements*** of the international application, this report is based on *(replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report)*:

Description, Pages

1-6, 8, 10-60	as originally filed
7, 9	filed with telefax on 27.07.2005

Claims, Numbers

1-73	filed with telefax on 27.07.2005

Drawings, Sheets

1/7-7/7	as originally filed

   ☐ a sequence listing and/or any related table(s) - see Supplemental Box Relating to Sequence Listing

3. ☐ The amendments have resulted in the cancellation of:
   - ☐ the description, pages
   - ☐ the claims, Nos.
   - ☐ the drawings, sheets/figs
   - ☐ the sequence listing *(specify)*:
   - ☐ any table(s) related to sequence listing *(specify)*:

4. ☐ This report has been established as if (some of) the amendments annexed to this report and listed below had not been made, since they have been considered to go beyond the disclosure as filed, as indicated in the Supplemental Box (Rule 70.2(c)).
   - ☐ the description, pages
   - ☐ the claims, Nos.
   - ☐ the drawings, sheets/figs
   - ☐ the sequence listing *(specify)*:
   - ☐ any table(s) related to sequence listing *(specify)*:

* *If item 4 applies, some or all of these sheets may be marked "superseded."*

INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY

International application No.
PCT/US2005/000623

Box No. II Priority

1. ☐ This report has been established as if no priority had been claimed due to the failure to furnish within the prescribed time limit the requested:
   - ☐ copy of the earlier application whose priority has been claimed (Rule 66.7(a)).
   - ☐ translation of the earlier application whose priority has been claimed (Rule 66.7(b)).
2. ☒ This report has been established as if no priority had been claimed due to the fact that the priority claim has been found invalid (Rule 64.1). Thus for the purposes of this report, the international filing date indicated above is considered to be the relevant date.
3. Additional observations, if necessary:

Box No. V Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Yes:	Claims	
	No:	Claims	1-73
Inventive step (IS)	Yes:	Claims	
	No:	Claims	1-73
Industrial applicability (IA)	Yes:	Claims	1-73
	No:	Claims	

2. Citations and explanations (Rule 70.7):

see separate sheet

Box No. VII Certain defects in the international application

The following defects in the form or contents of the international application have been noted:

see separate sheet

Box No. VIII Certain observations on the international application

The following observations on the clarity of the claims, description, and drawings or on the question whether the claims are fully supported by the description, are made:

see separate sheet

Re Item II

Priority

The publication date of WO 2004/016346 A (D1) lies between the filling date and the priority of the present application. D1 also discloses processes for conducting equilibrium limited chemical reactions flowing reactant compositions into at least two reaction zones, which comprise catalytic material and are in contact with a heat exchanger. These multiple reaction zones form theoretical equilibrium products and may achieve conversions of 40-95% in the first reaction zone. D1 discloses the production of methanol and the conversion in the second reaction zone of 50 to 99%. (See passages cited in the International Search Report.) Therefore, it appears that both D1 and the present application effectively claim the same invention, which would imply that the claimed the priority is not based on an application which was the first application of the invention. Consequently, according to Article 4.C(2) of the Paris Convention, the claimed priority seems to be invalid, insofar as it concerns the same invention. Under these circumstances, the subject-matter of the present application must be considered in the light of the prior art available at the filling date, which includes D1 and WO 2004/037418 A (D7).

Re Item V

Reasoned statement with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. The following documents (D) are referred to in this communication; the numbering will be adhered to in the rest of the procedure:

   D1: WO 2004/016346 A
   D2: DE 101 10 465 A1
   D3: WO 03/078052 A
   D4: US-B1-6 200 536
   D5: WO 01/54807 A
   D6: EP-A-0 903 174
   D7: WO 2004/037418 A

2. D1-D5 and D7 disclose microreactors and processes for conducting chemical reactions in a process channel comprising at least two zones havining catalytic material and in contact with a heat exchanger. The heat-exchange fluid may flow parallel (co- or countercurrent) or perpendicular to the process channel. The reaction zones may contain the same, or different catalytic material. Recycling part of the product stream is also disclosed. The catalytic material may be supported on a structure such as, among others, a wad, a foam or fins. The temperatures in the reaction zones may also be different, wherein the second zone may have either a higher or lower temperature. The cited documents also disclose apparatus comprising arrays of microchannels placed in parallel planes. The devices may be constructed out of, among others, stainless steel. These documents also disclose that when in use alternating planes of microchannels contain catalytic material and heat exchange fluid. The documents clearly disclose that a wide variety of reactions, such as, for example, water gas shift, methanol synthesis, methanation and dehydrogenation, may be carried out in these systems. D1, D3, D5 and D7 clearly disclose the use of the reactors for methanol synthesis (See passages cited in the International Search Report.)

3. Therefore, in light of D1, D3, D5 and D7, the subject-matter of claims 1-73 is not novel and does not fulfill the requirements of Article 33(2) PCT (see also item VIII-1 of the present communication).

4. D2 and D4 neither disclose the use of the microreactor for methanol synthesis nor for the synthesis of dimethyl ether. However, such a distinguishing feature is banal and would be an obvious modification for the skilled man in the art (Article 33(3) PCT).

   The applicant's attention is also drawn to the fact that D6 also discloses microreactor devices comprising different temperature zones along the reaction microchannel (see passages cited in the International Search Report). D6 does not disclose a process using heterogenous catalysts. However, it is well known in the art that microchannels may comprise such forms of catalysts (see for example, D1-D5 and D7). Such a distinguishing feature would be an obvious modification for the skilled man in the art without the exercise of inventive skill (Article 33(3) PCT).

Re Item VII

Certain defects in the international application

1. The following do not fulfill the requirements of Article 34(2)(b) PCT:

1.1. Original claim 74 included the intermediate product composition, which is not included in present claim 70.

1.2. Claims 71-73 include the terms "internal volume", such an expression cannot be found on page 56, line 30 to page 57, line 18.

1.3. Given that claim 1 now includes additional features, the applicant's attention is drawn to the fact that, during the regional phase, support for the new dependency may be requested.

2. Contrary to the requirements of Rule 5.1(a)(ii) PCT, the relevant background art disclosed in the documents D1-D4 is not mentioned in the description, nor are these documents identified therein.

3. When referencing prior art documents, the publication number should be used (see for example, page 46, line 24).

Re Item VIII

Certain observations on the international application

1. To fulfill the requirements of article 6 PCT the following have to be addressed:

1.1. Claim 1 requires on one hand that the conversion of the primary reactant in the first reaction zone be at least 5%, and one the other hand that the conversion be in the range of 5% to 95% per cycle. Such an inconsistency renders the claim unclear. A similar objection applies to the conversion defined in step c) of claim 1.

1.2. The expression "[...] for conversion .... at least about 5% [...]" in claims 1, 2 and the

expressions "[...] for conversion .... at least about 40% [...]", "[...] for conversion .... at least about 50% [...]", "[...] for conversion .... at least about 70% [...]", "[...] for conversion .... at least from about 75% to 95% [...]", in claims 69-74 attempt to define the subject-matter in terms of the result to be achieved, it does not contain any technical features (elements of the solution) necessary for achieving the result.

1.3. The independent claims of the present application comprise in step c) the feature " ... another reaction temperature in contact with another catalyst ... ". In claims 13 and 15, it is stated that the "another" catalyst may be the same or different, on the other hand it is clear from the application that the "another" temperature is a different temperature. Such inconsistencies in terminology render the claims and the application as a whole unclear. The same objection applies to the feature "additional catalyst" and "additional temperature" (see for example present claim 2). The applicant's attention is drawn to the fact that "another" catalyst in its common usage would mean a different catalyst.

1.4. In claims 1, 2, 18, 22, 54, 60-67 and 69-74 the term "about" is used when defining a range for certain parameters, such a formulation renders the claims unclear (see also, PCT Guidelines, III, 4.5a).

2. It is noted that throughout the application certain documents are incorporated by reference. The applicant's attention is drawn to the fact that certain member states may object to this formulation during the regional phase.

Fig. 10 is a schematic illustration of a process microchannel that may be used with the inventive process, the process microchannel containing a catalyst having a flow-by configuration.

Fig. 11 is a schematic illustration of a process microchannel that may be used with the inventive process, the process microchannel containing a catalyst having a flow-through configuration.

Fig. 12 is a schematic illustration of a process microchannel that may be used in the inventive process, the process microchannel containing a fin assembly comprising a plurality of fins, a catalyst being supported by the fins.

Fig. 13 illustrates an alternate embodiment of the process microchannel and fin assembly illustrated in Fig. 12.

Fig. 14 illustrates another alternate embodiment of the process microchannel and fin assembly illustrated in Fig. 12.

Fig. 15 is a graph containing a plot of the equilibrium conversion of CO to CH_3OH over a temperature range of 150°C to 310°C from a reactant composition containing 65% by volume H_2, 25% by volume CO, 5% by volume CO_2 and 5% by volume N_2.

Fig. 16 is a graph containing plots of CO conversion and dimethyl ether (DME) yield versus temperature for a dimethyl ether synthesis reaction, wherein the reactant composition contains 50% by volume CO and 50% by volume H_2.

Fig. 17 is a graph showing a plot of the equilibrium yield of CH_3OH and the expected yield of CH_3OH for the synthesis reaction reported in Example 1.

Detailed Description of the Invention

The term "equilibrium limited chemical reaction" refers to a chemical reaction or a set of complementary reactions that do not proceed to completion due to the fact that the reactants and the product(s) reach a state of equilibrium. The following reactions, which may be used in the synthesis of methanol, are examples of equilibrium limited chemical reactions:

Equation (1): $CO + H_2O \rightleftharpoons CO_2 + H_2$

Equation (2): $CO_2 + 3H_2 \rightleftharpoons CH_3OH + H_2O$

The term "microchannel reactor" refers to a reactor containing one or more microchannels adapted to receive a reactant composition which flows through the microchannels in contact with a catalyst and reacts to form product.

The term "reaction zone" refers to a space within the process microchannels wherein the reactants contact a catalyst at a particular temperature or within a particular temperature range and react.

The term "primary reactant" refers to one of the reactants in a chemical reaction. The primary reactant may or may not be present at the highest concentration of the reactants in the reactant composition. An example of a primary reactant is CO in the above-indicated methanol synthesis reaction represented by Equation (3).

The term "conversion of the primary reactant" refers to the primary reactant mole change between the reactant composition and a product (i.e., intermediate product composition, final product composition, etc.) divided by the moles of the primary reactant in the reactant composition.

The term "conversion of CO" refers to the CO mole change between the reactant composition and product (i.e., intermediate product composition, final product composition, etc.) divided by the moles of CO in the reactant composition.

The term "equilibrium conversion" for a reactant refers to the conversion of the reactant when, for a given initial composition, the reaction is allowed to reach equilibrium at a particular temperature, pressure and final composition. This can be determined using known techniques. To find the equilibrium conversion value for a reactant it is necessary to calculate the equilibrium composition. The composition of the final mixture is determined by the kinetic pathways allowed by the catalyst. In conducting equilibrium calculations for catalytic systems, all chemical species whose existence is favored thermodynamically at equilibrium need not be allowed to exist in the equilibrium mixture. For example, in the case of the low temperature water-gas shift reaction in which CO and H_2O combine to produce CO_2 and H_2O, if all methane is allowed to exist at equilibrium (by the provision of a kinetic pathway), then methane will be the primary product of the reaction. Under normal operating conditions commercial copper/zinc catalyst for water gas shift does not produce

Docket No. 03-020WO 61

Claims

1. A process for conducting an equilibrium limited chemical reaction to convert a reactant composition to a desired product, the desired product comprising methanol or dimethyl ether, the reactant composition comprising a primary reactant, the process comprising:

(A) determining the equilibrium conversion value for the primary reactant in the reactant composition at a first reaction temperature and at another reaction temperature;

(B) flowing the reactant composition through a first reaction zone in a microchannel reactor at the first reaction temperature in contact with a first catalyst to form an intermediate product composition, the intermediate product composition comprising the primary reactant and the desired product, the approach to equilibrium for conversion of the primary reactant in the first reaction zone being at least about 5%, the conversion of the primary reactant in the first reaction zone being in the range from about 5% to about 95% per cycle; and exchanging heat between the first reaction zone and a heat exchanger to maintain the temperature within the first reaction zone at the first reaction temperature; and

(C) flowing the intermediate product composition from the previous step through another reaction zone in the microchannel reactor at the another reaction temperature in contact with another catalyst to form the desired product, the approach to equilibrium for conversion of the primary reactant in the another reaction zone being at least about 5%, the conversion of the primary reactant in the another reaction zone being in the range from about 5% to about 99% per cycle; and exchanging heat between the another reaction zone and the heat exchanger to maintain the temperature within the another reaction zone at the another reaction temperature.

2. The process of claim 1 wherein the equilibrium conversion value for the primary reactant in the reactant composition at an additional reaction temperature between the first reaction temperature and the another reaction temperature is determined, and subsequent to step (B) but prior to step (C) the intermediate product composition formed in step (B) flows through an additional reaction zone in the microchannel reactor at the additional reaction temperature in

contact with an additional catalyst to form another intermediate product composition, the another intermediate product composition comprising the primary reactant and the desired product, the approach to equilibrium for the conversion of the primary reactant in the additional reaction zone being at least about 5%; and exchanging heat between the additional reaction zone and the heat exchanger to maintain the temperature within additional reaction zone at the additional reaction temperature.

3. The process of claim 1 wherein the approach to equilibrium for the conversion of the primary reactant in the first reaction zone, and the approach to equilibrium for the primary reactant in the another reaction zone are about the same.

4. The process of claim 2 wherein the approach to equilibrium for the conversion of the primary reactant in the first reaction zone, the approach to equilibrium for the conversion of the primary reactant in the another reaction zone, and the approach to equilibrium for the conversion of the primary reactant in the additional reaction zone are about the same.

5. The process of claim 1 wherein prior to the intermediate product composition entering the another reaction zone, the temperature of the intermediate product composition is changed from the first reaction temperature to the another reaction temperature.

6. The process of claim 2 wherein prior to the intermediate product composition entering the additional reaction zone, the temperature of the intermediate product composition is changed from the first reaction temperature to the additional reaction temperature.

7. The process of claim 1 wherein the equilibrium limited chemical reaction is an exothermic reaction.

8. The process of claim 1 wherein the another reaction temperature in step (C) is lower than the first reaction temperature in step (B).

9. The process of claim 2 wherein the additional reaction temperature is higher than the another reaction temperature in step (C) and lower than the first reaction temperature in step (B).

10. The process of claim 1 wherein the another reaction temperature in step (C) is higher than the first reaction temperature in step (B).

11. The process of claim 2 wherein the additional reaction temperature is lower than the another reaction temperature in step (C) and higher than the first reaction temperature in step (B).

12. The process of claim 1 wherein the first catalyst in step (B) is the same as the another catalyst in step (C).

13. The process of claim 2 wherein the additional catalyst is the same as the first catalyst in step (B), the another catalyst in step (C), or both the first catalyst in step (B) and the another catalyst in step (C).

14. The process of claim 1 wherein the first catalyst in step (B) is different than the another catalyst in step (C).

15. The process of claim 2 wherein the additional catalyst is different than the first catalyst in step (B), the another catalyst in step (C), or both the first catalyst in step (B) and the another catalyst in step (C).

16. The process of claim 1 wherein the microchannel reactor comprises a plurality of process microchannels.

17. The process of claim 16 wherein the process microchannels have internal dimensions of width or height of up to about 10 mm.

18. The process of claim 16 wherein the process microchannels are made of a material comprising: steel; monel; inconel; aluminum; titanium; nickel; copper; brass; an alloy of any of the foregoing metals; a polymer; ceramics; glass; a

composite comprising a polymer and fiberglass; quartz; silicon; or a combination of two or more thereof.

19. The process of claim 16 wherein the heat exchanger comprises at least one heat exchange channel adjacent to at least one process microchannel.

20. The process of claim 19 wherein the heat exchange channel comprises a microchannel.

21. The process of claim 20 wherein the heat exchange microchannel has an internal dimension of width or height of up to about 10 mm.

22. The process of claim 16 wherein the heat exchanger comprises at least one heat exchange channel adjacent to at least one process microchannel, the process microchannel having fluid flowing through it in one direction, the heat exchange channel having fluid flow through it in a direction that is counter-current to the flow of fluid through the process microchannel.

23. The process of claim 16 wherein the heat exchanger comprises at least one heat exchange adjacent to at least one process microchannel, the process microchannel having a fluid flowing through it in one direction, the heat exchange channel having fluid flow through it in a direction that is co-current to the flow of fluid through the process microchannel.

24. The process of claim 16 wherein the heat exchanger comprises a plurality of heat exchange channels adjacent to at least one process microchannel, the process microchannel having fluid flowing through it in one direction, the heat exchange channels having fluid flowing through them in a direction that is cross-current to the flow of fluids through the process microchannel.

25. The process of claim 16 wherein at least one process microchannel has an adjacent heat exchange channel, the length of the process microchannel and the length of the heat exchange channel being the same.

26. The process of claim 16 wherein at least one process microchannel has an adjacent heat exchange channel, the process microchannel having an entrance and an exit, the heat exchange channel extending lengthwise in the same direction as the process microchannel, the length of the heat exchange channel being shorter than the length of the process microchannel, the heat exchange channel being positioned at or near the process microchannel exit.

27. The process of claim 16 wherein the heat exchanger comprises a heat exchange zone adjacent to at least one process microchannel, the heat exchange zone comprising a plurality of heat exchange channels, the process microchannel having an entrance and an exit, the heat exchange channels extending lengthwise at a right angle relative to the lengthwise direction of the process microchannel, the heat exchange zone extending lengthwise in the same direction as the process microchannel, the length of the heat exchange zone being shorter than the length of the process microchannel, the heat exchange zone being positioned at or near the process microchannel exit.

28. The process of claim 16 wherein the heat exchanger comprises two heat exchange zones adjacent to at least one process microchannel, each heat exchange zone comprising a plurality of heat exchange channels, the heat exchange channels extending lengthwise at a right angle relative to the lengthwise direction of the process microchannel, the process microchannel having an entrance and an exit, the heat exchange zones extending lengthwise in the same direction as the process microchannel, the lengths of the heat exchange zones being shorter than the length of the process microchannel, the length of one of the heat exchange zones being shorter than the length of the other heat exchange zone, the heat exchange zones being positioned at or near the process microchannel exit.

29. The process of claim 19 wherein the heat exchange channel is made of a material comprising: steel; monel; inconel; aluminum; titanium; nickel; copper; brass; an alloy of any of the foregoing metals; a polymer; ceramics; glass; a composite comprising polymer and fiberglass; quartz; silicon; or a combination of two or more thereof.

30. The process of claim 19 wherein the process microchannel exchanges heat with a heat exchange fluid flowing through the heat exchange channel.

31. The process of claim 30 wherein the heat exchange fluid undergoes a phase change as it flows through the heat exchange channel.

32. The process of claim 19 wherein an endothermic process is conducted in the heat exchange channel.

33. The process of claim 32 wherein the endothermic process comprises a steam reforming reaction or a dehydrogenation reaction.

34. The process of claim 30 wherein the heat exchange fluid comprises air, steam, liquid water, carbon dioxide, gaseous nitrogen, a gaseous hydrocarbon or a liquid hydrocarbon.

35. The process of claim 1 wherein the first catalyst, the another catalyst, or both the first catalyst and the another catalyst are in the form of particulate solids.

36. The process of claim 16 wherein the first catalyst, the another catalyst, or both the first catalyst and the another catalyst are washcoated on interior walls of the process microchannels, grown on interior walls of the process microchannels from solution, or coated in situ on a fin structure.

37. The process of claim 1 wherein the first catalyst, the another catalyst, or both the first catalyst and the another catalyst are supported by a support structure made of a material comprising an alloy comprising Ni, Cr and Fe, or an alloy comprising Fe, Cr, Al and Y.

38. The process of claim 1 wherein the first catalyst, the another catalyst, or both the first catalyst and the another catalyst are supported on a support structure having a flow-by configuration, a flow-through configuration, or a serpentine configuration.

39. The process of claim 1 wherein the first catalyst, the another catalyst, or both the first catalyst and the another catalyst are supported on a support structure having the configuration of a foam, felt, wad, fin, or a combination of two or more thereof.

40. The process of claim 1 wherein the first catalyst, the another catalyst, or both the first catalyst and the another catalyst are supported on a support structure having a flow-by configuration with an adjacent gap, a foam configuration with an adjacent gap, a fin structure with gaps, a washcoat on a substrate, or a gauze configuration with a gap for flow.

41. The process of claim 1 wherein the first catalyst, the another catalyst, or both the first catalyst and the another catalyst are supported on a support structure in the form of a fin assembly comprising at least one fin

42. The process of claim 41 wherein the fin assembly comprises a plurality of parallel spaced fins.

43. The process of claim 41 wherein the fin has an exterior surface and a porous material overlies at least part of the exterior surface of the fin, the catalyst being supported by the porous material.

44. The process of claim 43 wherein the porous material comprises a coating, fibers, foam or felt.

45. The process of claim 41 wherein the fin has an exterior surface and a plurality fibers or protrusions extend from at least part of the exterior surface of the fin, the catalyst being supported by the protrusions.

46. The process of claim 41 wherein the fin has an exterior surface and the catalyst is: washcoated on at least part of the exterior surface of the fin; grown on at least part of the exterior surface of the fin from solution; or deposited on at least part of the exterior surface of the fin using vapor deposition.

47. The process of claim 41 wherein the fin assembly comprises a plurality of parallel spaced fins, at least one of the fins having a length that is different than the length of the other fins.

48. The process of claim 41 wherein the fin assembly comprises a plurality of parallel spaced fins, at least one of the fins having a height that is different than the height of the other fins.

49. The process of claim 41 wherein the fin has a cross section having the shape of a square, a rectangle, or a trapezoid.

50. The process of claim 41 wherein the fin is made of a material comprising: steel; aluminum; titanium; iron; nickel; platinum; rhodium; copper; chromium; brass; an alloy of any of the foregoing metals; a polymer; ceramics; glass; a composite comprising polymer and fiberglass; quartz; silicon; or a combination of two or more thereof.

51. The process of claim 41 wherein the fin is made of an alloy comprising Ni, Cr and Fe, or an alloy comprising Fe, Cr, Al and Y.

52. The process of claim 41 wherein the fin is made of an Al_2O_3 forming material or a Cr_2O_3 forming material.

53. The process of claim 16 wherein the process microchannels have a bulk flow path comprising about 5% to about 95% of the cross sections of such process microchannels.

54. The process of claim 1 wherein the reactant composition comprises H_2 and CO.

55. The process of claim 54 wherein the reactant composition further comprises H_2O, CO_2, N_2, a hydrocarbon of 1 to about 4 carbon atoms, or a mixture of two or more thereof.

56. The process of claim 1 wherein the contact time of the reactant composition and/or intermediate product composition with the catalyst in the first reaction zone is from about 10 to about 500 milliseconds.

57. The process of claim 1 wherein the contact time of the intermediate product composition and/or product with the catalyst in the another reaction zone is from about 10 to about 500 milliseconds.

58. The process of claim 1 wherein the temperature of the reactant composition entering the process microchannels is in the range of about 25°C to about 800°C.

59. The process of claim 1 wherein the temperature within the first reaction zone is from about 25°C to about 800°C.

60. The process of claim 1 wherein the temperature within the another reaction zone is from about 100°C to about 800°C.

61. The process of claim 1 wherein the pressure within the process microchannels is at least about 1 atmosphere.

62. The process of claim 1 wherein the pressure drop for the flow of the reactant composition and product through the process microchannels is up to about 40 atmospheres per meter of length of the process microchannels.

63. The process of claim 19 wherein a heat exchange fluid flows through the heat exchange channel, the pressure drop for the heat exchange fluid flowing through the heat exchange channel being up to about 50 atmospheres per meter of length of the heat exchange channel.

64. The process of claim 1 wherein the microchannel reactor has an entrance and an exit, the product exits the microchannel reactor through the exit, the product being intermixed with unreacted reactants from the reactant composition, and at least part of the unreacted reactants from the reactant composition being recycled to the entrance to the microchannel reactor.

65. The process of claim 1 wherein the approach to equilibrium for conversion of the primary reactant in the first reaction zone is at least about 40%, and the approach to equilibrium for conversion of the primary reactant in the another reaction zone is at least about 40%.

66. The process of claim 1 wherein the approach to equilibrium for the conversion of the primary reactant in the first reaction zone and in the another reaction zone is independently at least about 50%.

67. The process of claim 1 wherein the approach to equilibrium for the conversion of the primary reactant in the first reaction zone and in the another reaction zone is independently at least about 70%.

68. The process of claim 1 wherein the approach to equilibrium for the conversion of the primary reactant in the first reaction zone and in the another reaction zone is independently from about 75% to about 95%.

69. The process of claim 1 wherein the process is a process for conducting a methanol synthesis reaction, the approach to equilibrium for the conversion of the primary reactant in the first reaction zone being from about 75% to about 95%, the approach to equilibrium for the conversion of the primary reactant in the another reaction zone being from about 75% to about 95%.

70. The process of claim 1 wherein the process is a process for conducting a dimethyl ether synthesis reaction, the approach to equilibrium for the conversion of CO in the first reaction zone being from about 75% to about 95%, and the approach to equilibrium for the conversion of CO in the another reaction zone being from about 75% to about 95%.

71. The process of claim 16 wherein the total internal volume of the process microchannels in the microchannel reactor is up to about 1 liter, and the process produces the desired product at a rate of at least about 0.5 SLPM per liter of the internal volume of the process microchannels in the microchannel reactor.

72. The process of claim 16 wherein the contact time of the reactants and/or product with the catalyst in the microchannel reactor is up to about 1000 milliseconds, and the process produces the desired product at a rate of at least about 1 SLPM per liter of the internal volume of the process microchannels in the microchannel reactor.

73. The process of claim 16 wherein the process is conducted in a microchannel reactor containing at least one heat exchange channel, the total pressure drop for the heat exchange fluid flowing through the heat exchange channel being up to about 100 psi, and the process produces the desired product at a rate of at least about 0.5 SLPM per liter of the internal volume of the process microchannels in the microchannel reactor.

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